Influence of Heredity and Environment on Weaning and Post-Weaning Weights in Beef Cattle

By

JAMES HORACE MEADE, JR.

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Inherent biological factors create much variability in measurements taken to evaluate beef cattle performance. Some of this variability can be attributed to genetic differences between animals, some to environmental influences and some to genetic-environmental interactions. In order to accurately evaluate beef cattle performance, estimates of the various factors which influence performance are necessary. A thorough knowledge of these factors should enable the livestock breeder to develop more accurate breeding and selection programs.

During recent years there have been many papers published concerning the performance of different populations of beef cattle. However, due to environmental differences and genetic-environmental interactions, the livestock producer must have valid estimates of the factors influencing performance in the specific population which concerns him. This is particularly true in Florida because the environmental conditions are quite different from those prevailing throughout most of the United States. Therefore, the ability of an animal to adapt to his environment takes on added significance. Consequently, accurate estimates of the factors which influence beef cattle performance under Florida conditions should be of value to Florida cattlemen.

This study was undertaken with the purpose of obtaining estimates of genetic and environmental influences on weaning and post-weaning gains of beef cattle under south Florida conditions. The specific population involved was that of the Everglades Experiment Station beef cattle herd. This population contained Angus, Brahman, Devon, Brahman-Angus and Brahman-Devon cattle. Weaning weights were available for all calves. Also, since very little culling was practiced, 12- and 18-month weights were available for practically all heifers.

REVIEW OF LITERATURE

Weaning Performance

Effect of Year

Numerous investigations have shown that the effects of year cause the weaning weights of calves to fluctuate widely. Burgess, Landblom and Stonaker (1954) reported the effects of year on the weaning weight of Hereford calves. They obtained a range in year effects of 44 pounds for a six-year period. Similar year effects were found by Godbey *et al.* (1959), Brown (1960) and Godley *et al.* (1960). In a study of the Everglades Experiment Station beef cattle herd from 1931 to 1955, Clum (1956) obtained a range in year effects of over 100 pounds. Brown (1958) also obtained a range in year effects of over 100 pounds. Reynolds (1960) analyzed the records of the Range Cattle Experiment Station, Ona, Florida, for a 15-year period. He found that the range in year effects was 85 pounds.

Effect of Sex

The fact that sex has an effect on the weaning weights of calves has been known for some time. Koger and Knox (1945), using data collected over an eight-year period on 863 Hereford calves, determined the mean weaning weights of male and female calves corrected for differences

in weaning age. The average weaning weight was 443 pounds for 419 steers and 411 pounds for 444 heifers. The steers were heavier than the heifers each year. However, Gregory, Blunn and Baker (1950) found little difference in weaning weight between male and female calves. Botkin and Whatley (1953) analyzed the weaning weights of 701 calves produced by range Hereford cows and reported that the males averaged 25 pounds heavier than the females. In a review of the influence of sex of calf on weaning weight, Smith and Warwick (1953) determined that male calves averaged 23 to 49 pounds heavier than females. Bull calves were 22 pounds heavier and steer calves 2 pounds heavier than heifers at weaning in a study by Burgess, Landblom and Stonaker (1954). Rollins and Guilbert (1954) observed that bull calves were 68 pounds heavier than heifer calves at 240 days of age.

A study conducted by Koch and Clark (1955) showed that male calves averaged 26 pounds heavier at weaning than female calves. Clum (1956) noted that male calves averaged 25 pounds heavier at 180 days of age than females. Marlowe and Gaines (1958) averaged the records of 4166 calves in the Virginia performance testing program. The data were pooled over all years and over 44 Angus, 19 Hereford and 3 Shorthorn herds located in the state. At 210 days of age steers were 30 pounds heavier than heifers. Similar estimates were obtained by Koch (1951), Brown (1960), Reynolds (1960) and Meade, Hammond and Koger (1961). A difference of 41 pounds in favor of steer calves was reported by Godbey *et al*. (1959) and Godley *et al*. (1960).

Effect of Age of Dam

The age of the dam at calving has been shown to influence the weaning weights of calves to a certain extent. Knapp, Baker, Quesenberry and Clark (1942) observed that maximum weaning weights of calves may be expected from six-year-old cows with a gradual increase from two to six years and a more rapid decrease from six to 11 years. Knox and Koger (1945) showed that the age of maximum production of range cows was from six to eight years with the peak at seven years. Sawyer, Bogart and Oloufa (1949) noted that two-year-old cows weaned calves 75 pounds lighter than mature cows. The weaning weight of calves increased with increasing age of dams through eight years but then declined. Botkin and Whatley (1953) considered all cows five years old and older as mature. Weaning weights were adjusted to a mature cow equivalent by adding 35 and 15 pounds to the weights of calves from three- and four-year-old cows, respectively.

In a review of the influence of age of dam on calf weights, Smith and Warwick (1953) found that maximum weaning weights were usually obtained from dams six to nine years of age. Burgess, Landblom and Stonaker (1954) developed a series of constants to increase effectiveness of selection for weaning weights. They adjusted for age of dam by adding 15 pounds to calves from two-year-old cows, 10 pounds to calves from cows nine years and over, and subtracting 5 pounds from calves weaned by cows three to five years of age and 21 pounds from calves weaned by cows six to eight years of age. Koch and Clark (1955) used a number of correction factors to correct for the effect of age of dam

on weaning weight. They corrected by adding to the weaning weights of calves produced by: 3-year-old dams, 46 pounds; 4-year-old, 21 pounds; 5-year-old, 8 pounds; 6-year-old, 0 pounds; 7-year-old, 2 pounds; 8-year-old, 4 pounds; 9 year-old, 7 pounds; and 10-year-old, 14 pounds. McCormick and others (1956) determined that age of dam exerted a significant influence on 210-day weights of calves. Calves produced by two-year-old cows were 107 pounds lighter than those produced by eight-year-old cows. Calves from three-year-old dams were 63 to 73 pounds lighter than those from mature dams. Weaning weights of the calves produced gradually increased with age of dam until the cows reached maturity at seven or eight years of age.

Clum (1956) adjusted calf weights to a mature dam equivalent by adding 35, 12, 5, 3, 8, 18, 34, 53 and 53 pounds to calves from cows aged 2, 3, 4, 11, 12, 13, 14, 15 and 16 years, respectively. Marlowe and Gaines (1958) reported that maximum production was obtained from six- to eight-year-old cows. They made adjustments for age of dam on calves from cows that were 2, 3, 4, 5 and over 10 years of age at date of calving. Results similar to these were obtained by Brown (1958), Clark _et al_. (1958), Reynolds (1960) and Meade, Hammond and Koger (1961).

Effect of Month of Birth

Clum (1956) reported that within year variability due to month of birth influenced the 180-day weights of calves. He found that calves born in the months of December through May were heavier than

calves born from July through November. Peacock, Kirk and Koger (1956) stated that calves born during December, January and February were 14 pounds heavier at 180 days of age than calves born during March, April and May. Koger (1958) indicated that December and January calves were heavier than February, March or April calves. Results of a study by Marlowe, Kincaid and Litton (1958) gave evidence that season of birth contributed to the variability in preweaning gain. Brown (1958) reported that calves born during February, March and April were heavier than calves born from September through January. Reynolds (1960) found that the weaning weights of calves born from January through April were heavier by 7 pounds than calves born in December or May, and were 15 pounds heavier than those born from June through November. Marlowe and Gaines (1958) and Brown (1960) have also shown that season of birth influences the weaning weights of calves.

Effect of Lactation Status

Reynolds (1960) found that lactation status of the dam during the breeding season exerted a significant influence on weaning weight. He obtained an interaction of lactation status with pasture, year and breed. However, Meade, Hammond and Koger (1961) reported that lactation status of the dam did not influence weaning weight in a purebred Brahman herd.

Effect of Breed

Numerous investigations have shown that under specific environmental conditions breed of calf exerts a significant influence on

weaning weight. Bray (1933) reported that half-Brahman calves were heavier at weaning than either Hereford or Angus calves. In 1934, Black, Semple and Lush reported the results of mating Brahman bulls to Shorthorn and Hereford cows. At weaning, the steers containing Brahman blood were heavier than the non-Brahman steers. Phillips and others (1942) found that Shorthorn-Hereford steers out of Hereford cows were slightly heavier at weaning than purebred Hereford steers. For the Gulf Coast area, Rhoad and Black (1943) recommended Brahman hybrid beef-type bulls for use on range cows with one-half to three-fourths the blood of a pure beef breed. They stated that one parent of the hybrid bulls should be of the same pure beef breed that sired the range cows and the other parent predominately of Brahman breeding and of acceptable beef-type conformation.

In a study by Rhoad, Phillips and Dawson (1945), calves from Angus dams when mated to Angus bulls were lighter at six months of age than when mated to Africander or Zebu bulls. Baker and Black (1950) found that average weight at six months of age was significantly greater for calves out of Brahman-Angus cows than for calves out of purebred Angus cows, irrespective of sire. In a review, Warwick (1950) reported that Brahman crossbred calves were 35 pounds heavier at weaning than British type calves. Calves from Brahman crossbred dams were 81 pounds heavier at weaning than calves from British type cows. Gerlaugh, Kunkle and Rife (1951) made reciprocal crosses with Angus and Hereford cattle. The crossbred calves had only a slight advantage in weight at weaning over the purebreds.

Kidder and Chapman (1952) gave a preliminary report of weight performance of crossbred and purebred cattle at the Everglades Experiment Station. Their results indicated that progeny of reciprocal crosses of Brahman X Angus and Brahman X Devon were superior in weight gains to either of the purebred lines of the respective cross.

The results from 22 published experiments in crossbreeding beef cattle were appraised by Holt (1955). These included British breeds, other European breeds, Zebus and unimproved cattle. Crossbred calves averaged 3.5 per cent above the parental average in weaning weight. McCormick and Southwell (1955) summarized the weaning performance of British and British-Brahman F_1 calves. The British calves were 30 pounds lighter at weaning.

Kidder, Liddon, Clum and Koger (1956) analyzed the growth response of Angus, Brahman and Devon cattle and various crosses of these breeds. A marked heterosis effect on growth to 180 days resulted from the various Brahman-Devon crosses. Calves from crossbred dams by crossbred sires were lighter than F_1 calves or calves from crossbred dams by purebred sires. They stated that in the Angus-Brahman groups, heterosis effects were marked in both growth rate of calves and mothering ability of dams.

McComas, Cook and Dawson (1956) found that F_1 Red Dane X Red Poll heifers made more rapid gains from birth to weaning than did Red Poll heifers. Peacock, Kirk and Koger (1956) obtained a significant difference between weaning weights of calves mothered by dams of different breeding. Cows with one-half Brahman breeding weaned the heaviest calves and cows containing no Brahman breeding weaned the

lightest calves. Weaning weights of calves from cows with 1/32 to 15/32 and 17/32 to 31/32 Brahman breeding were intermediate. McCormick and Southwell (1957) stated that calves from Brahman bulls mated to Hereford cows were 27 pounds heavier at weaning than calves from Angus bulls mated to Hereford cows. Using a rotational crossbreeding system with Angus, Hereford and Shorthorn cattle, Quesenberry (1958) found that the crossbred steers weighed more at any age than did the Hereford steers with which they were compared.

Burns, Koger, Warnick and Kincaid (1959) reported that the weaning weights of Angus, Brahman and Hereford calves were lighter than Santa Gertrudis or Brahman-Angus calves. Damon et al. (1959) studied the performance of crossbred beef cattle in the Gulf Coast region. Crosses among Brahman and other breeds of cattle gave a considerable advantage over the purebred cattle with respect to weaning weights. However, the advantage was not so marked when slaughter calf grades were considered. These crosses were generally superior when the Brahman breeding was in the females. They obtained little advantage by crossing the English beef breeds. Godbey et al. (1959) reported that Angus cows produced lighter calves at weaning when mated to Angus bulls than when mated to Brahman or Hereford bulls. Likewise, Hereford cows produced lighter calves when mated to Hereford bulls than when mated to Angus or Brahman bulls. Godley et al. (1960) found that Brahman-Angus and Brahman-Hereford dams produced heavier calves than Hereford-Angus or purebred Angus dams when mated to the same Shorthorn bull.

Reynolds (1960) stated that breed group comparisons indicated that hybrid vigor was an important factor influencing growth of calves at the Range Cattle Station. Generally the breed groups with less than 75 per cent of any one breed weaned the heaviest calves. Hargrove (1960) individually fed Shorthorn, Brahman and Shorthorn X Brahman calves which were weaned at an average age of 86 days. The Shorthorn calves gained 169 pounds, the Brahman calves 224 pounds and the crossbred calves 238 pounds for a 147-day feeding period.

Post-Weaning Performance

Bray (1933) stated that half-Brahman yearling heifers averaged 733 pounds while beef type non-Brahman heifers averaged 649 pounds. Baker and Black (1950) found that yearling heifers out of Brahman-Angus cows were heavier than heifers out of purebred Angus cows. Warwick (1950) reported that Brahman crossbred cattle were 46 pounds heavier than British type cattle at 12 months of age. The crossbred cattle were 80 pounds heavier at 24 months of age.

Liddon (1957) studied post-weaning growth of Angus, Brahman, Devon and crossbred cattle at the Everglades Experiment Station. First-cross females were superior in weight to the two parental breeds from six months to five years of age. The F_1 females had a 7.7 to 18.7 per cent advantage over the heavier of the parental breeds. The 3/4 Devon backcross group was equal in weight to the Brahman-Devon F_1 groups. When all of the purebreds were compared with all of the crossbreds the crossbreds showed greater weight for age at all ages. Burns et al. (1959) reported that yearling Santa Gertrudis and Brahman-Angus

heifers were heavier than Angus, Brahman and Hereford heifers. McDowell et al. (1959) compared Jersey and Red Sindi-Jersey crossbred calves at the Beltsville and Jeanerette stations. They found that the F_1 calves were heavier than the purebred Jersey, 1/4 Jersey and 3/4 Jersey calves at 6, 12 and 18 months of age.

MATERIALS AND METHODS

Nature of Data

The data used in this study were obtained from the beef cattle records of the Everglades Experiment Station, Belle Glade, Florida. Records were available on Angus, Brahman, Devon and various crosses of these breeds of cattle. The Devon herd was established at the station in 1931 and maintained until 1960. Herds of purebred Angus and Brahman cattle were added and a crossbreeding program was started in 1946.

Very little culling took place in this population. Since practically all of the heifers were kept in the herd, little selection was practiced except for the choice of sires used. Therefore, the records used in this study were from a relatively unselected population compared to most beef cattle herds today.

The data analyzed were the 205-day weights of 933 calves and the 12- and 18-month weights of 415 heifers. All of the heifers having 12- and 18-month weights were included in the 205-day weight analysis. The records covered the ten-year period from 1950 through 1959. For 205-day weight, the data were classified by year of birth, breed group, age of dam, sex, month of birth and lactation status of the dam. For 12- and 18-month weights, the data were classified by year and breed group.

Although reproduction was not considered in this study, the number of cows bred and calves weaned by year and breed group is shown in table 16.

Factors Included in Analysis

The record of each individual was classified by year of birth and the following factors.

Age of Dam. Age of dam was classified six ways.

1. Two years. Heifers which calved at two years of age.
2. Three years. Cows which calved at three years of age.
3. Four years. Cows which calved at four years of age.
4. Five years. Cows which calved at five years of age.
5. Six to eleven years. Cows which calved from six to 11 years of age were grouped together since prior knowledge indicated that their influence on weaning weight was similar.
6. Twelve to seventeen. Since numbers were small in the higher age classifications, cows which calved from 12 to 17 years of age were grouped together.

Sex.

1. Bull calves.
2. Steer calves.
3. Heifer calves.

Month of Birth. Previous research and a preliminary inspection of the data indicated that month of birth could be grouped into three classifications.

1. Calves born during the months of December through June.
2. Calves born during the months of July through October.
3. Calves born in November.

Lactation Status of Dam. The term lactation status refers to the lactation record of the dam the previous year. It is based on whether or not a dam weaned a calf the previous year. In this study lactation status was classified two ways.

1. Lactating dams. Dams which weaned a calf the previous year.
2. Non-lactating dams. Dams which did not wean a calf the previous year.

Breed Group. Breed groups were classified on the basis of the breeding of the calf. There were three purebred groups and five crossbred groups as follows:

1. Angus. Purebred Angus calves.
2. Brahman. Purebred Brahman calves.
3. Devon. Purebred or high grade Devon calves.
4. Brahman-Angus F_1's. One-half Brahman one-half Angus calves.
5. Brahman-Angus Backcrosses. Calves obtained by mating Brahman or Angus bulls to Brahman-Angus F_1 dams.
6. Brahman-Devon F_1's. One-half Brahman one-half Devon calves.
7. Brahman-Devon Backcrosses. Calves obtained by mating Brahman or Devon bulls to Brahman-Devon F_1 dams.

8. Brahman-Devon Rotation Crosses. Calves resulting from a Brahman-Devon rotational mating system.

9. Inter-se. Calves resulting from the inter-se mating of Brahman-Devon crossbreds.

Method of Analysis

Like most animal breeding data the records in this study were not balanced with respect to their frequencies in the different subclasses. Therefore, a specialized statistical analysis was necessary in order to obtain the best estimates of the different parameters which were of interest. Various authors have discussed the problem of analyzing data involved in multiple classifications with disproportionate subclass frequencies. For data where the frequency of observations in some of the subclasses is zero, use of the method of fitting constants by least squares seems to be the best solution. This method of analysis was used in the present study.

Yates (1934) was the first to publish the method of least squares for the analysis of multiple classifications with unequal numbers in the different subclasses. Since then, others such as Hazel (1946), Anderson and Bancroft (1952), Kempthorne (1952), Henderson (1953) and Harvey (1960) have outlined this method and given the computational details involved in its use.

Due to the complexity of the data and the computational facilities available, it was impossible to analyze a model which included interaction effects by least squares. Consequently, it was necessary to use

some other method to obtain estimates of interaction. Estimates of all first-order interactions were obtained using an approximate method described by Hazel (1946) and Lundblom (1955). Sum of squares for interaction were obtained by summing the squared differences between actual and expected subclass values divided by their subclass frequency. Expected values were those obtained from the least squares analysis assuming no interaction. One degree of freedom was subtracted for each missing subclass in the two-way interaction tables.

Model for Weaning Data

The method of fitting constants by least squares was used to analyze the 205-day weights of 933 calves. The following mathematical model was assumed to fit the biology involved.

$$Y_{ijkpqrt} = u + y_i + b_j + a_k + s_p + m_q + l_r + e_{ijkpqrt}$$

$i = 1, 2, \ldots 10$

$j = 1, 2, \ldots 9$

$k = 1, 2, \ldots 6$

$p = 1, 2, 3$

$q = 1, 2, 3$

$r = 1, 2$

where:

$Y_{ijkpqrt}$ = the 205-day weight of the t^{th} calf in the $ijkpqr^{th}$ subclass,

u = the general mean,

y_i = effect of i^{th} year,

b_j = effect of j^{th} breed group,

a_k = effect of k^{th} age of dam,

s_p = effect of p^{th} sex,

m_q = effect of q^{th} month of birth,

l_r = effect of r^{th} lactation status of dam,

$e_{ijkpqrt}$ = random errors assumed to be NID $(0, \sigma_e^2)$.

Using this model, 34 least squares equations were derived and are shown in table 14. Since these equations were not independent, the following restrictions were imposed in order to obtain a solution.

$$\sum_i \hat{y}_i = \sum_j \hat{b}_j = \sum_k \hat{a}_k = \sum_p \hat{s}_p = \sum_q \hat{m}_q = \sum_r \hat{l}_r = 0$$

The reduced equations were solved simultaneously by using matrix inversion procedures. The matrix inverse is given in table 15. Sums of squares for main effects were computed by subtracting the reduction sum of squares, with a particular classification deleted, from the reduction sum of squares obtained with all elements in the model.

Model for Post-Weaning Data

The following mathematical model was used to analyze the 12- and 18-month weights of 415 heifers.

$$Y_{ijk} = \alpha + y_i + b_j + dD_{ijk} + e_{ijk}$$

$i = 1, 2, \ldots 10$

$j = 1, 2, \ldots 9$

where:

Y_{ijk} = the 12- or 18-month weight of the k^{th} heifer in the ij^{th} subclass,

α = the theoretical population mean with equal subclass frequencies when weaning age is zero,

y_i = effect of i^{th} year,

b_j = effect of j^{th} breed group,

d = partial regression of 12- or 18-month weight on age at weaning,

D_{ijk} = age at weaning for the k^{th} heifer in the ij^{th} subclass,

e_{ijk} = random errors assumed to be NID $(0, \sigma_e^2)$.

The restrictions were that $\sum_i \hat{y}_i = \sum_j \hat{b}_j = 0$. Estimates of the general mean were obtained from the relationship $\hat{u} = \hat{\alpha} + \hat{d}\,\bar{D}$, where $\bar{D}$ is the mean age at weaning.

RESULTS

205-Day Weight

The 205-day weights of 933 calves were used in this analysis. The unadjusted mean weight was 365 pounds while the adjusted mean or general mean obtained from the least squares analysis was 372 pounds.

Effect of Year

Differences in 205-day weights due to year effects were found to be highly significant ($P < 0.01$), as shown in table 1. In these data, years were an important source of variability as indicated by the mean square for year being more than twice as large as any other mean square. Although numerous reports state that year is an important source of variability, it seems that under the conditions of this study years were more variable than would be expected from a review of the literature.

Also, it is interesting to note that year was involved in all of the significant interactions (table 2). There were significant interactions of year with breed, sex, month of birth and lactation status. Age of dam was the only classification not involved in an interaction with year.

The least squares effects by year are given in table 3. The range in year effects was from 44 pounds in 1956 to -101 pounds in 1958.

Table 1.--VARIANCE ANALYSIS FOR MAIN EFFECTS INFLUENCING 205-DAY WEIGHTS

Source	df	SS	MS
R(u,y,b,a,s,m,l)	27	2,950,326	
R(u,b,a,s,m,l)	18	1,165,590	
R(u,y,a,s,m,l)	19	2,169,048	
R(u,y,b,s,m,l)	22	2,[illegible]47,548	
R(u,y,b,a,m,l)	25	2,770,747	
R(u,y,b,a,s,l)	25	2,905,954	
R(u,y,b,a,s,m)	26	2,946,747	
Year	9	1,784,737	198,304**
Breed	8	781,280	97,660**
Age of Dam	5	102,780	20,556**
Sex	2	179,580	89,790**
Month of Birth	2	44,373	22,187**
Lactation Status	1	3,581	3,581
Residual	905	3,344,204	3,695
Total	932	6,294,531	

**Significant at 0.01 level of probability.

Table 2.--APPROXIMATE MEAN SQUARES FOR FIRST-ORDER INTERACTIONS

Source	df	SS	MS
Year x Breed	58	373,507	6,440**
Year x Age of Dam	39	152,378	3,907
Year x Sex	16	138,161	8,635**
Year x Month of Birth	18	161,084	8,949**
Year x Lactation Status	9	75,251	8,361*
Breed x Age of Dam	33	147,680	4,475
Breed x Sex	16	93,015	5,813
Breed x Month of Birth	16	63,061	3,941
Breed x Lactation Status	8	28,822	3,603
Age of Dam x Sex	10	43,858	4,386
Age of Dam x Month of Birth	10	36,462	3,646
Age of Dam x Lactation Status	4	12,666	3,166
Sex x Month of Birth	4	11,216	2,804
Sex x Lactation Status	2	3,112	1,556
Month of Birth x Lactation Status	2	18,612	9,306

**Significant at 0.01 level of probability.
*Significant at 0.05 level of probability.

Table 3.--LEAST SQUARES EFFECTS BY YEAR[a]

Classification	Number of Calves	205-Day Weight
YEAR ($\hat{y}_i$)		
1950	49	38.31
1951	67	-21.19
1952	79	-1.88
1953	115	-15.63
1954	80	27.39
1955	107	39.11
1956	99	44.17
1957	141	20.34
1958	140	-100.56
1959	56	-30.05
OVER-ALL ($\hat{u}$)	933	372.28

[a]In this study, all effects are deviations from the over-all mean ($\hat{u}$).

Effect of Breed Group

There were highly significant differences in 205-day weights due to the effects of breed group. Also, there was a highly significant interaction of breed group with year. The Brahman-Angus backcross calves were the heaviest in this study with an effect of 50 pounds while the purebred Angus calves were the lightest with an effect of -49 pounds (table 4).

The purebred Devon calves were heavier than the purebred Brahman and Angus calves by 20 and 27 pounds, respectively. All of the purebred groups were lighter than any of the crossbred groups.

In the Brahman-Angus crosses, the backcross calves were 63 pounds heavier than the F_1 calves.

In the Brahman-Devon crosses, the backcross calves were 2 pounds heavier than the F_1 calves. The backcross calves were heavier than the rotation-cross and inter-se calves by 6 and 24 pounds, respectively.

The Brahman-Angus F_1 calves were 38 pounds lighter than the Brahman-Devon F_1 calves. In contrast to this, the Brahman-Angus backcross calves were 22 pounds heavier than the Brahman-Devon backcross calves.

Effect of Sex

Sex of calf was found to be a highly significant source of variability and was involved in a highly significant interaction with year.

Least squares estimates of the effects of sex revealed that bull calves were 11 pounds heavier than steer calves and ~~32~~ 20.3 pounds

Table 4.--LEAST SQUARES EFFECTS BY BREED

Classification	Number of Calves	205-Day Weight
BREED GROUP ($\hat{b}_j$)		
Purebreds		
Angus	143	-49.35
Brahman	67	-42.07
Devon	171	-22.52
Brahman-Angus Crosses		
F_1's	34	-12.74
Backcrosses	51	49.89
Brahman-Devon Crosses		
F_1's	82	25.28
Backcrosses	106	27.39
Rotation Crosses	102	20.98
Inter-se	177	3.12
OVER-ALL ($\hat{u}$)	933	372.28

heavier than heifer calves (table 5). These effects are similar to those reported by most research workers.

Effect of Age of Dam

There were highly significant differences due to age of dam. The heaviest calves were produced by cows which were six to 11 years old while the lightest calves were produced by cows which were two years old (table 5). Calves from cows 2, 3, 4, 5 and 12 through 17 years old were lighter than calves from cows six through 11 years old by 46, 26, 6, 12 and 5 pounds, respectively.

Effect of Lactation Status

The effects of lactation status were not significantly different. However, there was a significant ($P < 0.05$) interaction between lactation status and year.

The calves from cows which were non-lactating the previous year were 5 pounds heavier than calves from cows which were lactating the previous year (table 6).

Effect of Month of Birth

Month of birth exerted a highly significant influence on 205-day weights and was involved in a highly significant interaction with year. Calves born during the months of December through June were heavier than November calves by 7 pounds and July through October calves by 18 pounds (table 6).

Table 5.--LEAST SQUARES EFFECTS BY SEX AND AGE OF DAM

Classification	Number of Calves	205-Day Weight
SEX ($\hat{s}_p$)		
Bulls	281	14.28
Steers	173	3.02
Heifers	479	-17.30
AGE OF DAM ($\hat{a}_k$)		
2 years	61	-30.14
3 years	200	-10.40
4 years	155	9.42
5 years	151	4.30
6-11 years	333	15.82
12-17 years	33	11.00
OVER-ALL ($\hat{u}$)	933	372.28

Table 6.--LEAST SQUARES EFFECTS BY LACTATION STATUS AND MONTH OF BIRTH

Classification	Number of Calves	205-Day Weight
LACTATION STATUS ($\hat{l}_r$)		
Lactating	497	-2.44
Non-lactating	436	2.44
MONTH OF BIRTH ($\hat{m}_q$)		
December-June	368	8.32
July-October	249	-10.09
November	316	1.77
OVER-ALL ($\hat{u}$)	933	372.28

12- and 18-Month Weight

The 12- and 18-month weights of 415 heifers were used in this analysis. The unadjusted mean weight was 488 pounds for the heifers at 12 months of age and 630 pounds for the heifers at 18 months of age. The adjusted means for the 12- and 18-month-old heifers were 485 and 632 pounds, respectively.

Effect of Year of Birth

Year of birth exerted a highly significant influence on the 12- and 18-month weights of the heifers in this study (tables 7 and 8). The magnitudes of the mean squares for year in respect to breed were similar to that found in the 205-day weight analysis where the year mean square was more than twice as large as the breed mean square.

The year x breed interaction mean squares are given in table 9 and are not significant. There was tremendous variability in the year effects (table 10). The range in year effects for 12-month weight was 166 pounds while for 18-month weight it was 215 pounds.

Effect of Breed Group on 12-Month Weight

There were highly significant differences in the 12-month weights due to breed group. The purebred Angus heifers were the lightest breed group while the Brahman-Devon F_1 heifers were the heaviest (table 11).

The purebred Devon heifers were 18 pounds heavier than the Brahman heifers and 76 pounds heavier than the Angus heifers.

Table 7.--VARIANCE ANALYSIS FOR 12-MONTH WEIGHT

Source	df	SS	MS
R(α,y,b,dD)	18	2,027,398	
R(α,b,dD)	9	617,455	
R(α,y,dD)	10	1,407,129	
R(α,y,b)	17	1,886,742	
Year	9	1,409,944	156,660**
Breed	8	620,269	77,534**
Regression of Weight on Age at Weaning	1	140,656	140,656**
Residual	396	1,396,746	3,527
Total	414	3,424,145	

**Significant at 0.01 level of probability.

Table 8.--VARIANCE ANALYSIS FOR 18-MONTH WEIGHT

Source	df	SS	MS
R(α,y,b,dD)	18	2,530,362	
R(α,b,dD)	9	523,763	
R(α,y,dD)	10	1,887,560	
R(α,y,b)	17	2,512,703	
Year	9	2,006,599	222,955**
Breed	8	642,802	80,350**
Regression of Weight on Age at Weaning	1	17,659	17,659
Residual	396	1,830,853	4,623
Total	414	4,361,215	

**Significant at 0.01 level of probability.

Table 9.--INTERACTION OF YEAR WITH BREED

Source	df	SS	MS
Year x Breed (12-Month Weight)	54	225,262	4,171.5
Year x Breed (18-Month Weight)	54	336,091	6,223.9

Table 10.--LEAST SQUARES EFFECTS OF YEAR OF BIRTH ON 12- AND 18-MONTH WEIGHTS

Classification	Number of Heifers	12-Month Weight	18-Month Weight
YEAR ($\hat{y}_i$)			
1950	28	-6.22	-15.54
1951	35	-54.46	-49.15
1952	29	-50.90	-37.30
1953	45	-47.76	-52.50
1954	31	-23.83	4.70
1955	47	111.85	106.36
1956	50	87.32	129.76
1957	63	54.51	-84.94
1958	60	-50.18	30.52
1959	27	-20.33	-31.91
OVER-ALL ($\hat{u}$)	415	485.46	631.90

Table 11.--LEAST SQUARES EFFECTS OF BREED ON 12- AND 18-MONTH WEIGHTS

Classification	Number of Heifers	12-Month Weight	18-Month Weight
BREED GROUP ($\hat{b}_j$)			
Purebreds			
Angus	52	-89.00	-85.59
Brahman	33	-30.89	-47.94
Devon	67	-12.99	-3.61
Brahman-Angus Crosses			
F_1's	17	29.98	58.94
Backcrosses	22	5.25	-5.13
Brahman-Devon Crosses			
F_1's	45	58.72	64.12
Backcrosses	48	29.85	18.96
Rotation Crosses	48	26.83	21.71
Inter-se	83	-17.75	-21.46
OVER-ALL ($\hat{u}$)	415	485.46	631.90

In the Brahman-Angus crosses, the F_1 heifers were 25 pounds heavier than the backcross heifers. Both the F_1 and backcross groups were heavier than the purebred Angus and Brahman heifers.

In the Brahman-Devon crosses, the F_1 heifers were 29 pounds heavier than the backcross heifers. The F_1 heifers were 32 pounds heavier than the rotation-cross heifers and 76 pounds heavier than the inter-se heifers. All of the Brahman-Devon crosses were heavier than the purebred Brahman and Devon heifers with the exception of the inter-se heifers. The inter-se heifers were 13 pounds heavier than the Brahman heifers but were 5 pounds lighter than the Devon heifers.

The Brahman-Devon F_1 and backcross heifers were 29 and 25 pounds heavier than the Brahman-Angus F_1 and backcross heifers.

Effect of Breed Group on 18-Month Weight

Breed group exerted a highly significant influence on 18-month weights. The purebred Angus heifers were the lightest breed group while the Brahman-Devon F_1 heifers were the heaviest (table 11).

The purebred Devon heifers were 44 pounds heavier than the Brahman heifers and 82 pounds heavier than the Angus heifers.

In the Brahman-Angus crosses, the F_1 heifers were 64 pounds heavier than the backcross heifers.

In the Brahman-Devon crosses, the F_1 heifers were 45 pounds heavier than the backcross heifers. The F_1 heifers were 42 pounds heavier than the rotation-cross heifers and 86 pounds heavier than the inter-se heifers.

The Brahman-Devon F_1 and backcross heifers were 5 and 24 pounds heavier than the Brahman-Angus F_1 and backcross heifers.

The purebred Angus and Brahman heifers were lighter than any of the crossbred groups. The purebred Devon heifers were heavier than the inter-se and Brahman-Angus backcrosses but lighter than the other crossbred groups.

Regression of Weight on Age at Weaning

Table 12 gives the partial regression coefficients for the regression of 12- and 18-month weights on age of calf at weaning. The partial regression coefficients are 0.77 pounds for 12-month weight and 0.27 pounds for 18-month weight.

Table 12.--PARTIAL REGRESSION COEFFICIENTS FOR REGRESSION OF WEIGHT ON AGE AT WEANING

	12-Month Weight	18-Month Weight
Regression of 12- and 18-Month Weight on Age at Weaning	0.7744585	0.2744128

Influence of Age of Dam

In order to determine if calves from two- and three-year-old cows were as heavy at 12- and 18-months of age as calves from older cows, age of dam was placed in the post-weaning model. This gave a valid comparison of the heifers from the two- and three-year-old cows and the older cows. Using this comparison, there were no significant differences in the 12- or 18-month weights due to the influence of age of dam.

DISCUSSION

In general, the results of this study are in agreement with the published reports of other similar investigations. However, the environmental conditions during the period of this study caused the dependent variables to fluctuate widely. This is shown by the tremendous year to year variability in the 205-day, 12- and 18-month weights. An indication of the magnitude of the year effects is shown in table 13. The square of the multiple correlation coefficient gives the amount of variability in the dependent variable that can be explained by a knowledge of the independent variables. It is interesting to note that if year is omitted from the model only about 18 per cent of the variability can be explained by a knowledge of the other independent variables. However, when year is included in the model R^2 is increased to approximately 47 per cent. Breed group was the only other classification which changed R^2 greatly when omitted from the model.

Even though most research workers agree that year effects are an important source of variability, the variation in year effects found in this study is greater than would be expected from a review of the literature. It is interesting to note that year was involved in significant interactions with breed group, sex, month of birth and lactation status. None of the other first-order interactions was significant. Also, it should be pointed out that even though there was a highly significant

Table 13.--MULTIPLE CORRELATION COEFFICIENTS WITH CERTAIN CLASSIFICATIONS OMITTED FROM MODEL

Classification Omitted	R	R^2
All Elements in Model	0.6846	0.4687
Year	0.4303	0.1852
Breed Group	0.5870	0.3446
Age of Dam	0.6726	0.4524
Sex	0.6635	0.4402
Month of Birth	0.6795	0.4617
Lactation Status	0.6842	0.4681

year x breed group interaction for 205-day weight there were no significant interactions for 12- and 18-month weights. From these results the following statements about the Everglades Experiment Station beef cattle population appear to be justified:

1. Environmental influences create much variability in beef cattle weights.
2. Experiments involving beef cattle should be designed so that the desired comparisons can be made on a within year basis.
3. Since year was involved in all significant interactions, experiments should be repeated for several years before any definite conclusions are drawn.

The effects of sex were in close agreement with most estimates obtained under different conditions. Almost all investigations have revealed that bulls are heavier than steers and that steers are heavier than heifers. The same situation was true in this study. However, contrary to most reports, sex was involved in an interaction with year. This may be due to the fact that the year to year variation was extremely great.

The variability due to age of dam in this study was less than that usually reported. The differences between the two- and three-year-old cows and the mature cows were not as great as those obtained in most studies. The fact that age of dam did not influence 12- and 18-month weights gives validity to the practice of adjusting weaning weights for the effects of age of dam before replacements are selected.

The significant influence of month of birth indicates that this factor should be considered in beef cattle research at the Everglades Experiment Station.

Lactation status of the dam the previous year did not exert a significant influence on weaning weights. Even though the effect of lactation status was not significant, the calves from cows which were non-lactating the previous year were 5 pounds heavier than calves from cows which were lactating. Also, there was a significant interaction ($P < 0.05$) between lactation status and year. However, the multiple correlation coefficients obtained with lactation status in and out of the model were practically the same. Therefore, very little precision was gained by including lactation status in the model.

There were significant differences ($P < 0.01$) in the 205-day, 12- and 18-month weights due to the influence of the different breed groups. With the exception of year, breed group was the largest source of variability in the 205-day weights. Since one of the primary objectives of crossbreeding is to increase weaning weights, this variability created by breed groups would be expected if the breeding programs under consideration were successful. The results of this study clearly point out that increased weaning weights can be obtained through the use of crossbreeding programs involving Angus, Brahman and Devon cattle at the Everglades Experiment Station. Even though this is true, careful consideration should be given to other important factors before a crossbreeding program is used in an economic enterprise. Certainly the reproductive rate should be considered since it probably influences economic return more than any one single factor.

All of the crossbred groups in this study involved the Brahman breed of cattle. This means that rate of reproduction should be evaluated even more critically because most evidence indicates that the rate of

reproduction in Brahman cattle may be lower than in some of the other breeds. Also, there is the possibility of partial genetic incompatibility between the Brahman and European breeds of cattle as far as reproduction is concerned (Koger, 1960). Other very important factors to be considered are the practical limitations of crossbreeding programs.

The relative influence of breed group on 205-day, 12- and 18-month weights is shown in figure 1. At 205 days of age, all of the purebred groups were lighter than any crossbred group. For the Brahman and Angus groups, this held true at 12 and 18 months of age. However, the Devon heifers were heavier than the inter-se heifers at 12 and 18 months of age and heavier than the Brahman-Angus backcross heifers at 18 months.

It is interesting to compare the F_1's and backcrosses at different ages. At 205 days of age, the Brahman-Angus and Brahman-Devon backcross calves were the two heaviest breed groups. However, at 12 and 18 months of age they were considerably lighter than their respective F_1 breed groups. Since these calves from F_1 dams were heavier at weaning but were lighter at later ages, it seems plausible to state that the F_1 cattle expressed hybrid vigor in the form of growth potential and milking or mothering ability.

In general, the Brahman-Devon inter-se cattle did not perform as well as the F_1, backcross and rotation-cross breed groups. A possible explanation for this is the loss of hybrid vigor in the inter-se matings.

With the exception of the Brahman-Devon F_1 and backcross groups, the Brahman-Devon rotation-cross cattle were the only breed group whose weights were above the mean of the population at all ages. Considering

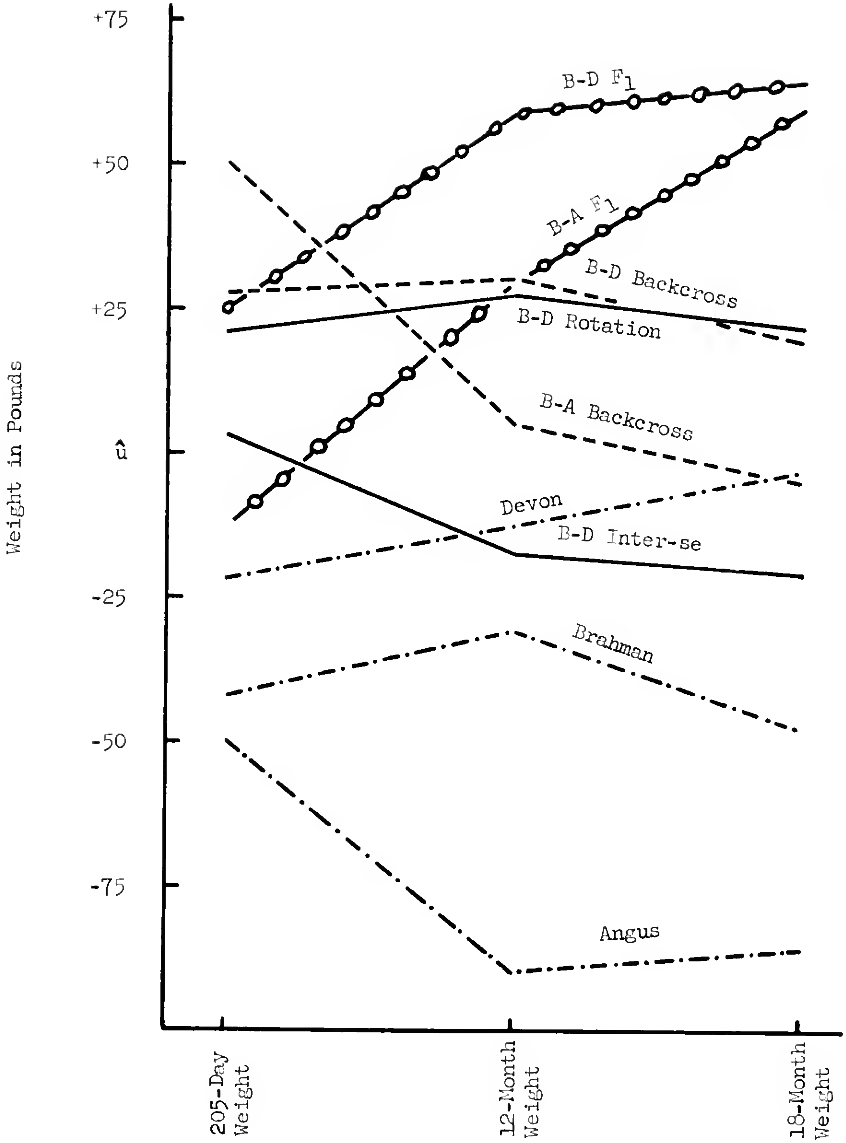

Figure 1. Relative influence of breed group on 205-day, 12-month and 18-month weights.

only the weights of the different breed groups and the practical aspects of the different breeding programs involved, the Brahman-Devon rotation-cross cattle may possibly be one of the best breed groups in this population from an economic viewpoint.

The regression coefficients obtained from the post-weaning analysis point out one interesting fact. Age differences within a breeding season do not influence the 18-month weights of heifers very much. This is indicated by a partial regression coefficient of 0.27 pounds for the regression of 18-month weights on age at weaning. If the same situation prevails in beef cattle under other conditions, care should be taken in the interpretation of the commonly used measurement "weight per day of age."

SUMMARY

Estimates of the factors which influenced the 205-day, 12- and 18-month weights of the Everglades Experiment Station beef cattle population were obtained using the method of fitting constants by least squares. This population contained Angus, Brahman, Devon, Brahman-Angus and Brahman-Devon cattle. The 205-day weights of 933 calves and the 12- and 18-month weights of 415 heifers were included in the analyses. The records covered the ten-year period from 1950 through 1959.

There was tremendous variability in the year effects. The ranges in year effects were 145 pounds for 205-day weight, 166 pounds for 12-month weight and 215 pounds for 18-month weight. All of the significant first-order interactions were involved with year.

Bull calves were 11 pounds heavier than steer calves and 32 pounds heavier than heifer calves at 205 days of age.

The heaviest calves were produced by cows which were six to 11 years old while the lightest calves were produced by cows which were two years old. Calves from cows 2, 3, 4, 5 and 12 through 17 years old were lighter than calves from cows six through 11 years old by 46, 26, 6, 12 and 5 pounds, respectively.

There was a significant influence of month of birth on 205-day weights. Calves born during the months of December through June were heavier than November calves by 7 pounds and July through October calves by 18 pounds.

The effects of lactation status were not significantly different. However, there was a significant ($P < 0.05$) interaction between lactation status and year.

All of the purebred breed groups were lighter than any of the crossbred groups at 205 days of age. For the Brahman and Angus groups, this held true at 12 and 18 months of age. However, the Devon heifers were heavier than the inter-se heifers at 12 and 18 months of age and heavier than the Brahman-Angus backcross heifers at 18 months.

The Brahman-Angus and Brahman-Devon backcross calves were the two heaviest breed groups at 205 days of age. At 18 months of age, the Brahman-Angus and Brahman-Devon F_1 heifers were the heaviest breed groups. With the exception of the Brahman-Devon F_1 and backcross groups, the Brahman-Devon rotation-cross cattle were the only breed group whose weights were above the mean of the population at all ages. The Brahman-Devon inter-se cattle did not perform as well as the F_1, backcross and rotation-cross breed groups.

Partial regression coefficients of 0.77 and 0.27 pounds were obtained for the regression of 12- and 18-month weights on age at weaning, respectively.

APPENDIX

Table 14.--ORIGINAL LEAST SQUARES EQUATIONS

	$\hat{u}$	$\hat{y}_0$	$\hat{y}_1$	$\hat{y}_2$	$\hat{y}_3$	$\hat{y}_4$	$\hat{y}_5$	$\hat{y}_6$	$\hat{y}_7$	$\hat{y}_8$	$\hat{y}_9$
u :	933	49	67	79	115	80	107	99	141	140	56
y_0:	49	49									
y_1:	67		67								
y_2:	79			79							
y_3:	115				115						
y_4:	80					80					
y_5:	107						107				
y_6:	99							99			
y_7:	141								141		
y_8:	140									140	
y_9:	56										56
b_1:	143	4	1	11	7	17	14	18	25	30	16
b_2:	67	4	6	12	5	4	11	2	7	11	5
b_3:	171	9	20	22	25	9	19	21	25	12	9
b_4:	34	5	7		8	7	6			1	
b_5:	51			2	9	1	4	7	11	12	5
b_6:	82	20	19	6	15	4		7	6	5	
b_7:	106	7	14	23	22	11	5		5	14	5
b_8:	102				6	12	19	17	21	20	7
b_9:	177			3	18	15	29	27	41	35	9
a_1:	61	3	5	13	17		5	3	15		
a_2:	200	9	10	11	24	24	13	24	24	36	25
a_3:	155	6	9	7	14	7	31	12	34	24	11
a_4:	151	16	10	12	11	13	15	23	15	23	13
a_5:	333	15	33	33	42	31	37	33	48	54	7
a_6:	33			3	7	5	6	4	5	3	
s_1:	281	13	22	35	17	18	28	41	5	78	24
s_3:	173	2	8	6	43	25	22	2	65		
s_5:	479	34	37	38	55	37	57	56	71	62	32
m_1:	368	14	25	56	54	42	41	43	35	39	19
m_2:	249	26	15	10	30	15	25	34	61	26	7
m_3:	316	9	27	13	31	23	41	22	45	75	30
l_1:	497	16	37	42	62	51	36	54	70	99	30
l_2:	436	33	30	37	53	29	71	45	71	41	26

Table 14 (continued)

$\hat{b}_1$	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_4$	$\hat{b}_5$	$\hat{b}_6$	$\hat{b}_7$	$\hat{b}_8$	$\hat{b}_9$
143	67	171	34	51	82	106	102	177
4	4	9	5		20	7		
1	6	20	7		19	14		
11	12	22		2	6	23		3
7	5	25	8	9	15	22	6	18
17	4	9	7	1	4	11	12	15
14	11	19	6	4		5	19	29
18	2	21		7	7		17	27
25	7	25		11	6	5	21	41
30	11	12	1	12	5	14	20	35
16	5	9		5		5	7	9
143								
	67							
		171						
			34					
				51				
					82			
						106		
							102	
								177
6		9		11		16	4	15
36	16	36	2	13	1	31	18	47
22	6	20	4	10	6	15	29	43
19	12	21	6	9	18	17	16	33
45	33	74	18	8	57	25	34	39
15		11	4			2	1	
60	24	53	7	17	19	27	32	42
18	6	32	9	10	14	25	20	39
65	37	86	18	24	49	54	50	96
51	28	70	12	23	24	44	45	71
57	10	43	12	14	30	26	12	45
35	29	58	10	14	28	36	45	61
89	33	78	16	24	54	63	55	85
54	34	93	18	27	28	43	47	92

Table 14 (continued)

$\hat{a}_1$	$\hat{a}_2$	$\hat{a}_3$	$\hat{a}_4$	$\hat{a}_5$	$\hat{a}_6$	$\hat{s}_1$	$\hat{s}_3$	$\hat{s}_5$
61	200	155	151	333	33	281	173	479
3	9	6	16	15		13	2	34
5	10	9	10	33		22	8	37
13	11	7	12	33	3	35	6	38
17	24	14	11	42	7	17	43	55
	24	7	13	31	5	18	25	37
5	13	31	15	37	6	28	22	57
3	24	12	23	33	4	41	2	56
15	24	34	15	48	5	5	65	71
	36	24	23	54	3	78		62
	25	11	13	7		24		32
6	36	22	19	45	15	60	18	65
	16	6	12	33		24	6	37
9	36	20	21	74	11	53	32	86
	2	4	6	18	4	7	9	18
11	13	10	9	8		17	10	24
	1	6	18	57		19	14	49
16	31	15	17	25	2	27	25	54
4	18	29	16	34	1	32	20	50
15	47	43	33	39		42	39	96
61						11	26	24
	200					71	26	103
		155				38	46	71
			151			45	16	90
				333		106	54	173
					33	10	5	18
11	71	38	45	106	10	281		
26	26	46	16	54	5		173	
24	103	71	90	173	18			479
44	74	57	64	115	14	102	81	185
10	49	45	39	96	10	68	55	126
7	77	53	48	122	9	111	37	168
	35	91	103	242	26	158	85	254
61	165	64	48	91	7	123	88	225

Table 14 (continued)

$\hat{m}_1$	$\hat{m}_2$	$\hat{m}_3$	$\hat{i}_1$	$\hat{i}_2$	RIIM
368	249	316	497	436	340,789
14	26	9	16	33	19,878
25	15	27	37	30	23,726
56	10	13	42	37	29,012
54	30	31	62	53	41,166
42	15	23	51	29	31,721
41	25	41	36	71	43,636
43	34	22	54	45	40,843
35	61	45	70	71	53,969
39	26	75	99	41	38,384
19	7	30	30	26	18,454
51	57	35	89	54	45,223
28	10	29	33	34	21,934
70	43	58	78	93	60,824
12	12	10	16	18	12,657
23	14	14	24	27	20,479
24	30	28	54	28	33,130
44	26	36	63	43	40,463
45	12	45	55	47	40,596
71	45	61	85	92	65,483
44	10	7		61	22,089
74	49	77	35	165	69,104
57	45	53	91	64	58,318
64	39	48	103	48	55,671
115	96	122	242	91	123,857
14	10	9	26	7	11,750
102	68	111	158	123	102,418
81	55	37	85	88	67,758
185	126	168	254	225	170,613
368			199	169	137,810
	249		126	123	90,247
		316	172	144	112,732
199	126	172	497		160,171
169	123	144		436	160,618

Table 15.--INVERSE OF REDUCED COEFFICIENT MATRIX[a]

	$\hat{y}_0$	$\hat{y}_1$	$\hat{y}_2$	$\hat{y}_3$	$\hat{y}_4$	$\hat{y}_5$
y_0:	.207126	-.007837	-.013852	-.017593	-.029396	-.024643
y_1:		.147307	-.009012	-.009006	-.019945	-.018841
y_2:			.130372	-.006557	-.016361	-.013958
y_3:				.090040	-.006385	-.007476
y_4:					.120971	-.009101
y_5:						.097266
y_6:						
y_7:						
y_8:						
b_1:						
b_2:						
b_3:						
b_5:						
b_6:						
b_7:						
b_8:						
b_9:						
a_1:						
a_2:						
a_3:						
a_4:						
a_5:						
s_1:						
s_5:						
m_1:						
m_3:						
l_1:						

[a]Symmetric Matrix.
Inverse of corrected sum of squares and crossproducts.
Values in table are actual values divided by 10.

Table 15 (continued)

$\hat{y}_6$	$\hat{y}_7$	$\hat{y}_8$	$\hat{b}_1$	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_5$
-.022348	-.025341	-.026596	.012222	.000565	.001234	.020518
-.019904	-.019765	-.01[illegible]943	.014176	-.000107	-.005718	.017283
-.013687	-.018210	-.010150	.006186	-.013020	-.006457	.008594
-.001146	.001705	-.009907	.008221	.003319	-.000879	-.003140
-.001106	-.003501	-.007231	-.005162	.005105	.005972	.003462
-.005804	.002277	-.003972	-.002078	-.004111	.002160	.002985
.101362	-.004854	-.000177	-.003515	.007774	-.002479	-.008940
	.088716	-.004878	-.006562	-.000482	-.000520	-.011577
		.0[illegible]2104	-.006114	.001444	.006125	-.012592
			.077159	-.012082	-.000994	-.011084
				.136038	-.007661	-.028184
					.062045	-.017001
						.181293

Table 15 (continued)

$\hat{b}_6$	$\hat{b}_7$	$\hat{b}_8$	$\hat{b}_9$	$\hat{a}_1$	$\hat{a}_2$	$\hat{a}_3$
-.045771	-.002347	.016208	.019182	-.005705	.002531	-.002950
-.027235	-.008983	.017805	.016532	-.010982	.000559	-.003092
-.000476	-.020689	.012764	.008395	-.013933	.007878	.002677
-.003821	-.003884	.005485	.002193	-.010563	.000843	.006697
.010941	.000353	-.006770	-.003146	.012694	-.007781	.006907
.018611	.005336	-.009916	-.009729	.013375	.012567	-.007581
.006894	.010824	-.013114	-.011252	.005837	-.001090	.003209
.013753	.011478	-.012005	-.012104	-.002086	.003718	.000286
.013838	.002497	-.006733	-.009322	.005321	-.004757	-.001366
-.016111	-.005943	-.002171	.002989	-.001184	-.000659	.003850
-.014552	-.013173	-.013895	-.010659	.011735	-.004641	.000777
-.003895	-.003530	-.005019	-.000913	.008520	.000996	.002703
-.035263	-.017285	-.012973	-.005395	-.030934	-.002120	-.000389
.135222	-.009499	-.020978	-.017818	.015146	.006573	.001836
	.098140	-.012974	-.005089	-.016733	-.008631	.002953
		.100624	.004666	-.000932	.000509	-.009891
			.066826	-.008922	-.005057	-.005893
				.167941	-.006960	-.022807
					.064634	-.002839
						.067073

Table 15 (continued)

$\hat{a}_4$	$\hat{a}_5$	$\hat{s}_1$	$\hat{s}_5$	$\hat{m}_1$	$\hat{m}_3$	$\hat{l}_1$
-.010636	.005841	-.003384	-.005694	.002349	.007414	.005833
.001732	-.000542	-.003473	-.001349	-.000836	-.001332	-.000565
.003302	-.001169	-.008599	-.000500	-.001069	.005455	.000500
.008803	.002621	.009527	.003153	-.000695	.000946	-.001994
.000286	-.003006	.007388	.003873	-.003748	.000302	-.002870
.000369	-.004699	.003071	.000470	.000937	-.002030	.007577
-.003711	-.000731	-.006041	-.002191	-.000491	.004433	-.000561
.004802	-.001145	.017772	.003630	.008291	-.001057	.000053
.000569	-.002527	-.010756	.001053	.003351	-.006662	-.004782
.007580	.007495	-.005046	.000733	.000844	.005272	-.002799
-.005150	-.008426	-.001768	-.001002	-.001659	-.002627	.002066
.002186	-.003076	-.000399	.000791	-.000494	-.000642	.002603
.002711	.012559	-.003158	-.000502	-.001555	.002866	-.002251
-.006820	-.017392	.003875	-.000142	.003117	-.001749	.000492
.003358	.009540	.003797	.000130	.003328	-.001476	-.005727
-.000519	.000934	-.001925	.000062	-.003947	-.002922	.000525
-.001731	.006554	.000697	-.001449	-.001377	.000420	-.000576
-.003022	-.029371	.004351	.005108	-.009395	.003367	.017911
-.003471	-.001230	-.002436	-.000513	.000906	-.001313	.011865
-.001066	.004428	.003152	.002359	.002415	-.000285	-.003842
.069369	.007765	-.000575	-.002437	.000921	.000133	-.006581
	.048407	-.001668	-.000987	.003754	-.001176	-.008700
		.032351	-.004597	.002224	-.002210	-.000134
			.020650	.000411	-.001080	.000246
				.022868	-.009693	-.001600
					.024046	.000276
						.016677

Table 16.--COWS BRED AND CALVES WEANED BY YEAR AND BREED GROUP[a]

	Year									
	1951		1952		1953		1954		1955	
	B	W	B	W	B	W	B	W	B	W
Purebreds										
Angus	7	1	14	11	9	7	19	17	17	14
Brahman	10	6	15	12	9	5	14	4	14	11
Devon	27	20	42	22	30	25	16	9	32	19
Brahman-Angus Crosses										
F_1's	10	7	0	0	9	8	11	7	10	6
Backcrosses	0	0	2	2	9	9	8	1	5	4
Brahman-Devon Crosses										
F_1's	21	19	7	6	22	15	20	4	1	0
Backcrosses	14	14	24	23	24	22	19	11	8	5
Rotation Crosses	1	0	3	0	7	6	22	12	32	19
Inter-se	0	0	4	3	19	18	33	15	48	29
Totals	90	67	111	79	138	115	162	80	167	107
Weaning Per Cent	74.4		71.2		83.3		49.4		64.1	

[a]Cows bred are classified by breed of expected calf.

Table 16 (continued)

	Year										
	1956		1957		1958		1959		Totals		Weaning Per Cent
	B	W	B	W	B	W	B	W	B	W	
Purebreds											
Angus	24	18	32	25	36	30	24	16	182	139	76.4
Brahman	16	2	16	7	17	11	15	5	126	63	50.0
Devon	42	21	40	25	35	12	16	9	280	162	57.9
Brahman-Angus Crosses											
F_1's	0	0	0	0	1	1	0	0	41	29	70.7
Backcrosses	9	7	13	11	16	12	8	5	70	51	72.9
Brahman-Devon Crosses											
F_1's	17	7	12	6	9	5	0	0	109	62	56.9
Backcrosses	0	0	7	5	15	14	7	5	118	99	83.9
Rotation Crosses	27	17	27	21	29	20	18	7	166	102	61.4
Inter-se	52	27	57	41	54	35	29	9	296	177	59.8
Totals	187	99	204	141	212	140	117	56	1388	884	
Weaning Per Cent	52.9		69.1		66.0		47.9				63.7

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BIOGRAPHICAL SKETCH

James H. Meade, Jr. was born November 1, 1932, at Vicksburg, Mississippi. He graduated from Jett Vocational High School in 1950. In May, 1954, he received the degree Bachelor of Science in Agriculture from Mississippi State University. After serving two years in the United States Army, the author returned to Mississippi State University where he received the degree Master of Science in Agriculture in January, 1959.

The author is now a candidate for the degree Doctor of Philosophy at the University of Florida.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Agriculture and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

June 5, 1961

Dean, College of Agriculture

Dean, Graduate School

Supervisory Committee:

Chairman